HEWLETT PACKARD

AC/DC to Logic Interface Optocoupler

Technical Data

HCPL-3700 4.53
HCPL-3760 4.72

Features

- Standard and Low Input Current (HCPL-3760) Versions
- AC or DC Input
- Programmable Sense Voltage
- Hysteresis
- Logic Compatible Output
- Thresholds Guaranteed Over Temperature
- Thresholds Independent of LED Degradation
- Recognized Under the Component Program of U.L. (File No. E55361) for Dielectric Withstand Proof Test Voltages of 2500 VAC, 1 Minute
- VDE 0883 Approval Available

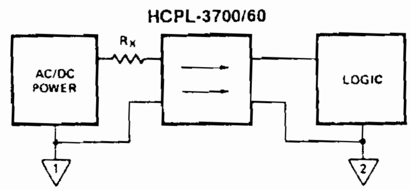
Applications

- Limit Switch Sensing
- Low Voltage Detector
- 5 V-240 V AC/DC Voltage Sensing
- Relay Contact Monitor
- Relay Coil Voltage Monitor
- Current Sensing
- Microprocessor Interfacing

Description

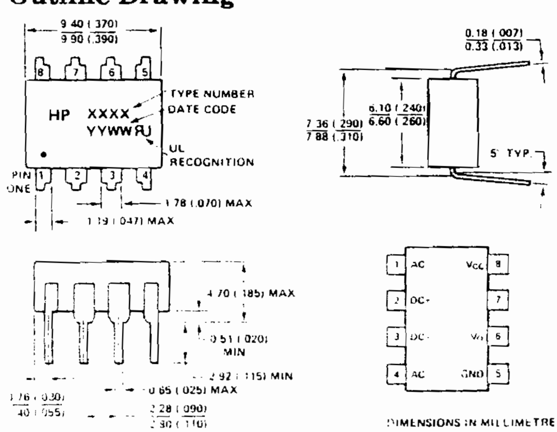
The HCPL-3700 and HCPL-3760 are voltage/current threshold detection optocouplers. The HCPL-3760 is a low-current version of the HCPL-3700. To obtain lower current operation, the HCPL-3760 uses a high-efficiency AlGaAs LED which provides higher light output at lower drive currents. Both devices utilize threshold sensing input buffer ICs which permit control of threshold levels over a wide range of input voltages with a single external resistor.

The input buffer incorporates



several features: hysteresis for extra noise immunity and switching immunity, a diode bridge for easy use with ac input signals, and internal clamping diodes to protect the buffer and LED from a wide range of over-voltage and over-current transients. Because

Outline Drawing



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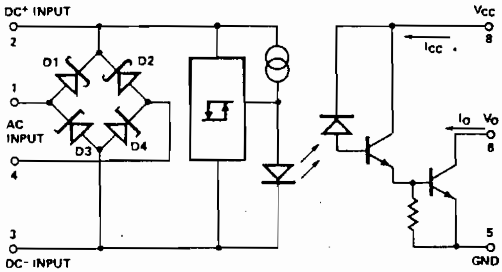
threshold sensing is done prior to driving the LED, variations in optical coupling from the LED to the detector will have no effect on the threshold levels.

The HCPL-3700's input buffer IC has a nominal turn on threshold of 2.5 mA (I_{TH} +) and 3.7 volts (V_{TH} +).

The buffer IC for the HCPL-3760 was redesigned to permit a lower input current. The nominal turn on threshold for the HCPL-3760 is 1.2 mA (I_{TH} +) and 3.7 volts (V_{TH} +).

The high gain output stage features an open collector output providing both TTL compatible saturation voltages and CMOS compatible breakdown voltages.

Schematic



By combining several unique functions in a single package, the user is provided with an ideal component for industrial control computer input boards and other applications where a predetermined input threshold level is desirable.

Absolute Maximum Ratings (No derating required up to 70°C)

Parameter		Symbol	Min.	Max.	Units	Note
Storage Temperature		T_S	-55	125	°C	
Operating Temperature		T_A	-40	85	°C	
Lead Soldering Cycle	Temperature			260	°C	1
	Time			10	sec	
Input Current	Average	I_{IN}		50	mA	2
	Surge			140		2, 3
	Transient			500		
Input Voltage (Pins 2-3)		V_{IN}	-0.5		V	
Input Power Dissipation		P_{IN}		230	mW	4
Total Package Power Dissipation		P		305	mW	5
Output Power Dissipation		P_O		210	mW	6
Output Current	Average	I_O		30	mA	7
Supply Voltage (Pins 8-5)		V_{CC}	-0.5	20	V	
Output Voltage (Pins 6-5)		V_O	-0.5	20	V	

Recommended Operating Conditions

Parameter	Symbol	Min.	Max.	Units	Note
Supply Voltage	V_{CC}	2	18	V	
Operating Temperature	T_A	0	70	°C	
Operating Frequency	f	0	4	KHz	8

Electrical Specifications

Over Recommended Temperature T_A = 0°C to 70°C, Unless Otherwise Specified.

Parameter	Sym.	Device	Min.	Typ.[9]	Max.	Units	Conditions	Fig.	Note
Input Threshold Current	I_{TH+}	HCPL-3700	1.96	2.5	3.11	mA	$V_{IN} = V_{TH+}$; V_{CC} = 4.5 V; V_O = 0.4 V; $I_O \geq$ 4.2 mA	2, 3	14
		HCPL-3760	0.87	1.2	1.56	mA			
	I_{TH-}	HCPL-3700	1.00	1.3	1.62	mA	$V_{IN} = V_{TH-}$; V_{CC} = 4.5 V; V_O = 2.4 V; $I_{OH} \leq$ 100 µA		
		HCPL-3760	0.43	0.6	0.80	mA			
Input Threshold Voltage — DC (Pins 2, 3)	V_{TH+}		3.35	3.7	4.05	V	$V_{IN} = V_2 - V_3$; Pins 1 & 4 Open; V_{CC} = 4.5 V; V_O = 0.4 V; $I_O \geq$ 4.2 mA		
	V_{TH-}		2.01	2.6	2.86	V	$V_{IN} = V_2 - V_3$; Pins 1 & 4 Open; V_{CC} = 4.5 V; V_O = 2.4 V; $I_O \leq$ 100 µA		
Input Threshold Voltage — AC (Pins 1, 4)	V_{TH+}		4.23	4.9	5.50	V	$V_{IN} = \lvert V_1 - V_4 \rvert$; Pins 2 & 3 Open; V_{CC} = 4.5 V; V_O = 0.4 V; $I_O \geq$ 4.2 mA		14, 15
	V_{TH-}		2.87	3.7	4.20	V	$V_{IN} = \lvert V_1 - V_4 \rvert$; Pins 2 & 3 Open; V_{CC} = 4.5 V; V_O = 2.4 V; $I_O \leq$ 100 µA		
Hysteresis	I_{HYS}	HCPL-3700		1.2		mA	$I_{HYS} = I_{TH+} - I_{TH-}$	2	
		HCPL-3760		0.6		mA			
	V_{HYS}			1.2		V	$V_{HYS} = V_{TH+} - V_{TH-}$		
Input Clamp Voltage	V_{IHC1}		5.4	6.0	6.6	V	$V_{IHC1} = V_2 - V_3$; V_3 = GND; I_{IN} = 10 mA; Pin 1 & 4 Connected to Pin 3	1	
	V_{IHC2}		6.1	6.7	7.3	V	$V_{IHC2} = \lvert V_1 - V_4 \rvert$; $\lvert I_{IN} \rvert$ = 10 mA; Pins 2 & 3 Open		
	V_{IHC3}			12.0	13.4	V	$V_{IHC3} = V_2 - V_3$; V_3 = GND; I_{IN} = 15 mA; Pins 1 & 4 Open		
	V_{ILC}			-0.76		V	$V_{ILC} = V_2 - V_3$; V_3 = GND; I_{IN} = -10 mA		
Input Current	I_{IN}	HCPL-3700	3.0	3.7	4.4	mA	$V_{IN} = V_2 - V_3$ = 5.0 V Pins 1 & 4 Open	5	
		HCPL-3760	1.5	1.8	2.2	mA			
Bridge Diode Forward Voltage	$V_{D1,2}$	HCPL-3700		0.59		V	I_{IN} = 3 mA		
		HCPL-3760		0.51		V	I_{IN} = 1.5 mA		
	$V_{D3,4}$	HCPL-3700		0.74		V	I_{IN} = 3 mA		
		HCPL-3760		0.71		V	I_{IN} = 1.5 mA		

OPTOCOUPLERS

Electrical Specifications (Continued)

Parameter	Sym.	Device	Min.	Typ.*	Max.	Units	Conditions	Fig.	Note
Logic Low Output Voltage	V_{OL}			0.1	0.4	V	V_{CC} = 4.5 V; I_{OL} = 4.2 mA	5	14
Logic High Output Current	I_{OH}				100	µA	V_{OH} = V_{CC} = 18 V		14
Logic Low Supply Current	I_{CCL}	HCPL-3700		1.2	4	mA	$V_2 - V_3$ = 5.0 V; V_O = Open; V_{CC} = 5.0 V		
		HCPL-3760		0.7	3				
Logic High Supply Current	I_{CCH}			0.002	4	µA	V_{CC} = 18 V; V_O = Open	4	14
Input-Output Insulation	V_{ISO}		2500			V_{RMS}	RH ≤ 50%, t = 1 min; T_A = 25°C		16
Input-Output Resistance	R_{I-O}			10^{12}		Ω	V_{I-O} = 500 VDC		16
Input-Output Capacitance	C_{I-O}			0.6		pF	f = 1 MHz; V_{I-O} = 0 VDC		
Input Capacitance	C_{IN}			50		pF	f = 1 MHz; V_{IN} = 0 V, Pins 2 & 3, Pins 1 & 4 Open		

*For JEDEC registered parts.

Switching Specifications

T_A = 25°C, V_{CC} = 5.0 V Unless Otherwise Specified

Parameter	Sym.	Device	Min.	Typ.	Max.	Units	Test Conditions	Fig.	Note
Propagation Delay Time to Logic Low at Output	t_{PHL}	HCPL-3700		4.0	15.0	µs	R_L = 4.7 kΩ, C_L = 30 pF	6, 9	10
		HCPL-3760		4.5					
Propagation Delay Time to Logic High at Output	t_{PLH}	HCPL-3700		10.0	40.0	µs	R_L = 4.7 kΩ, C_L = 30 pF		11
		HCPL-3760		8.0					
Output Rise Time (10-90%)	t_r	HCPL-3700		20		V/µs	R_L = 4.7 kΩ, C_L = 30 pF	7	
		HCPL-3760		14					
Output Fall Time (90-10%)	t_f	HCPL-3700		0.3		V/µs	R_L = 4.7 kΩ, C_L = 30 pF		
		HCPL-3760		0.4					
Common Mode Transient Immunity at Logic Low Output	$\|CM_H\|$			4000		V/µs	I_{IN} = 0 mA, R_L = 4.7 kΩ, $V_{O\,min}$ = 2.0 V, V_{CM} = 1400 V	8, 10	12, 13
Common Mode Transient Immunity at Logic High Output	$\|CM_L\|$	HCPL-3700		600		V/µs	I_{IN} = 3.11 mA; R_L = 4.7 kΩ, $V_{O\,max}$ = 0.8 V, V_{CM} = 140 V		
		HCPL-3760					I_{IN} = 1.56 mA		

Insulation Related Specifications

Parameter	Symbol	Value	Units	Conditions
Min. External Air Gap (Clearance)	L (IO1)	≥ 7	mm	Measured from input terminals to output terminals
Min. External Tracking Path (Creepage)	L (IO2)	≥ 7	mm	Measured from input terminals to output terminals
Min. Internal Plastic Gap (Clearance)		0.08	mm	Through insulation distance conductor to conductor
Tracking Resistance	CTI	175	Volts	DIN IEC 112/VDE 0303 Part 1
Isolation Group (per DIN VDE 0109)		IIIa		Material Group DIN VDE 0109

Notes:

1. Measured at a point 1.6 mm below seating plane.
2. Current into/out of any single lead.
3. Surge input current duration is 3 ms at 120 Hz pulse repetition rate. Transient input current duration is 10 μs at 120 Hz pulse repetition rate. Note that maximum input power, P_{IN}, must be observed.
4. Derate linearly above 70°C free-air temperature at a rate of 4.1 mW/°C. Maximum input power dissipation of 230 mW allows an input IC junction temperature of 125°C at an ambient temperature of T_A = 70°C with a typical thermal resistance from junction to ambient of θ_{JAI} = 240°C W. Excessive P_{IN} and T_J may result in IC chip degradation.
5. Derate linearly above 70°C free-air temperature at a rate of 5.4 mW/°C.
6. Derate linearly above 70°C free-air temperature at a rate of 3.9 mW/°C. Maximum output power dissipation of 210 mW allows an output IC junction temperature of 125°C at an ambient temperature of T_A = 70°C with a typical thermal resistance from junction to ambient of θ_{JAO} = 265°C/W.
7. Derate linearly above 70°C free-air temperature at a rate of 0.6 mA/°C.
8. Maximum operating frequency is defined when output waveform Pin 6 obtains only 90% of V_{CC} with R_L = 4.7 kΩ, C_L = 30 pF using a 5 V square wave input signal.
9. All typical values are at T_A = 25°C, V_{CC} = 5.0 V unless otherwise stated.
10. The t_{PHL} propagation delay is measured from the 2.5 V level of the leading edge of a 5.0 V input pulse (1 μs rise time) to the 1.5 V level on the leading edge of the output pulse (see Figure 9).
11. The t_{PLH} propagation delay is measured from the 2.5 V level of the trailing edge of a 5.0 V input pulse (1 μs fall time) to the 1.5 V level on the trailing edge of the output pulse (see Figure 9).
12. Common mode transient immunity in Logic High level is the maximum tolerable (positive) $dV_{CM/dt}$ on the leading edge of the common mode pulse, V_{CM}, to insure that the output will remain in a Logic High state (i.e., V_O > 2.0 V). Common mode transient immunity in Logic Low level is the maximum tolerable (negative) $dV_{CM/dt}$ on the trailing edge of the common mode pulse signal, V_{CM}, to insure that the output will remain in a Logic Low state (i.e., V_O < 0.8 V). See Figure 10.
13. In applications where $dV_{CM/dt}$ may exceed 50,000 V/μs (such as static discharge), a series resistor, R_{CC}, should be included to protect the detector IC from destructively high surge currents. The recommended value for R_{CC} is 240Ω per volt of allowable drop in V_{CC} (between Pin 8 and V_{CC}) with a minimum value of 240Ω.
14. Logic low output level at Pin 6 occurs under the conditions of $V_{IN} \geq V_{TH+}$ as well as the range of $V_{IN} > V_{TH-}$ once V_{IN} has exceeded V_{TH+}. Logic high output level at Pin 6 occurs under the conditions of $V_{IN} \leq V_{TH-}$ as well as the range of $V_{IN} < V_{TH+}$ once V_{IN} has decreased below V_{TH-}.
15. AC voltage is instantaneous voltage.
16. Device considered a two terminal device: Pins 1, 2, 3, 4 connected together, and Pins 5, 6, 7, 8 connected together.

OPTOCOUPLERS

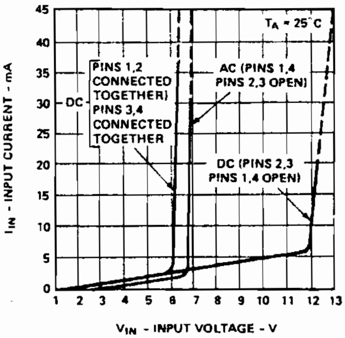


Figure 1. Typical Input Characteristics, I_{IN} vs. V_{IN} (AC Voltage is Instantaneous Value).

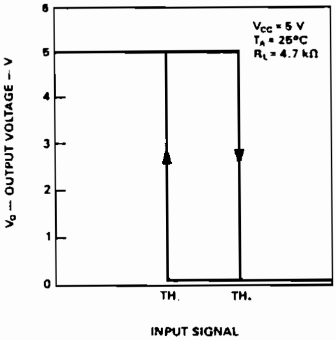


Figure 2. Typical Transfer Characteristics.

	DEVICE	TH_+	TH_-	INPUT CONNECTION
I_{TH}	HCPL-3700	2.5 mA	1.3 mA	PINS 2, 3
	HCPL-3760	1.2 mA	0.6 mA	OR 1, 4
$V_{TH(dc)}$	BOTH	3.7 V	2.6 V	PINS 2, 3
$V_{TH(ac)}$	BOTH	4.9 V	3.8 V	PINS 1, 4

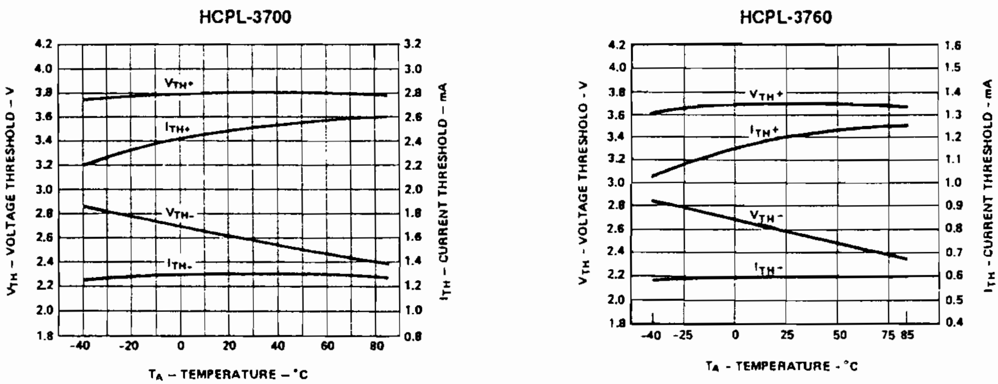


Figure 3. Typical DC Threshold Levels vs. Temperature.

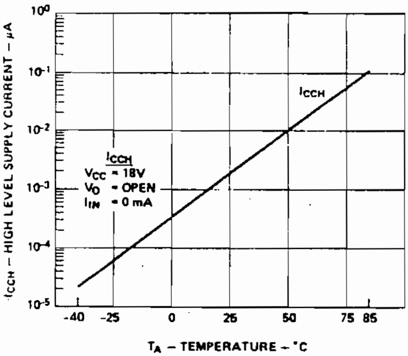


Figure 4. Typical High Level Supply Current, I_{CCH} vs. Temperature.

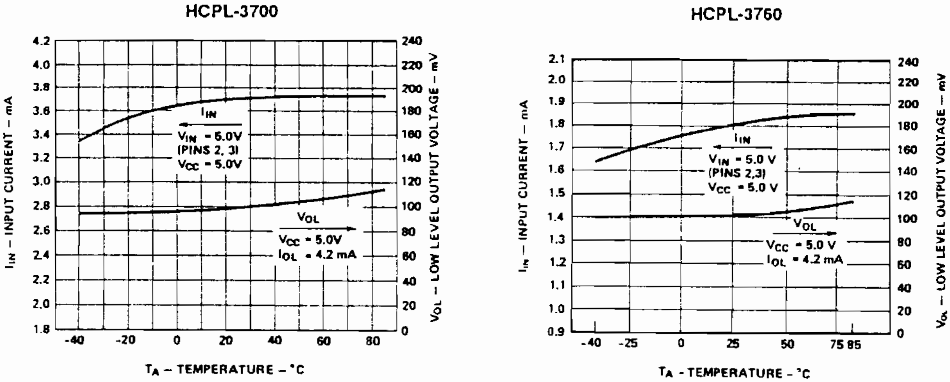


Figure 5. Typical Input Current, I_{IN}, and Low Level Output Voltage, V_{OL}, vs. Temperature.

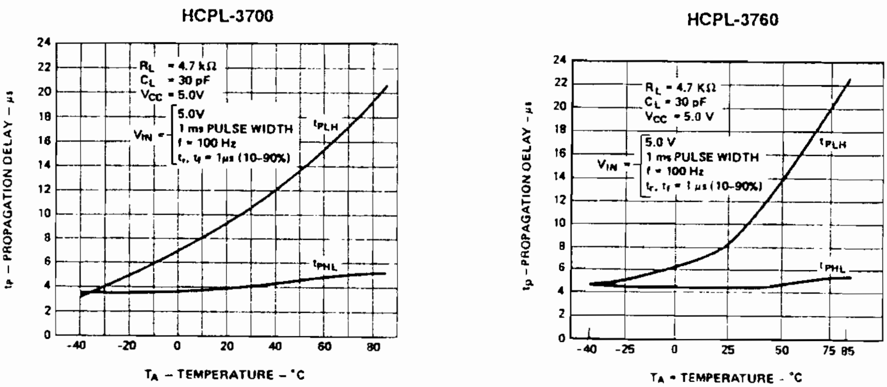


Figure 6. Typical Propagation Delay vs. Temperature.

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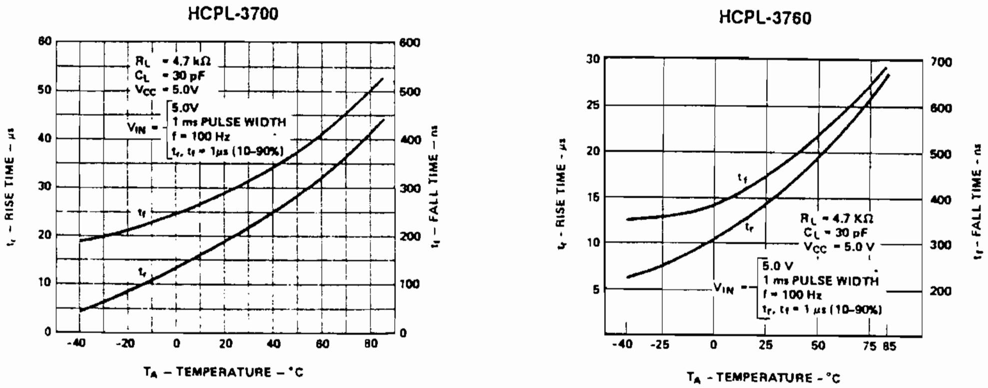

Figure 7. Typical Rise, Fall Times vs. Temperature.

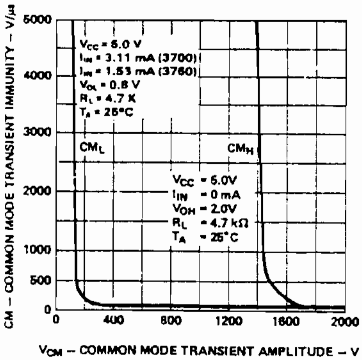

Figure 8. Common Mode Transient Immunity vs. Common Mode Transient Amplitude.

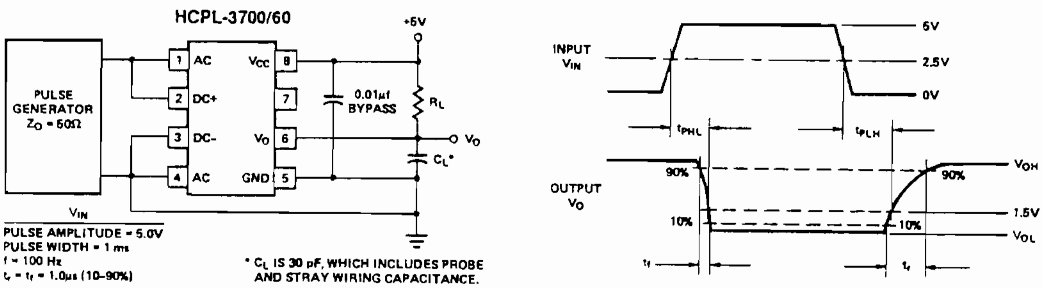

Figure 9. Switching Test Circuit.

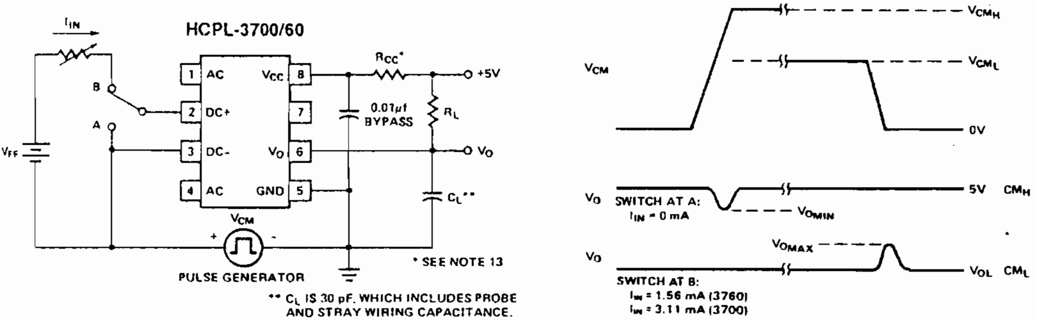

Figure 10. Test Circuit for Common Mode Transient Immunity and Typical Waveforms.

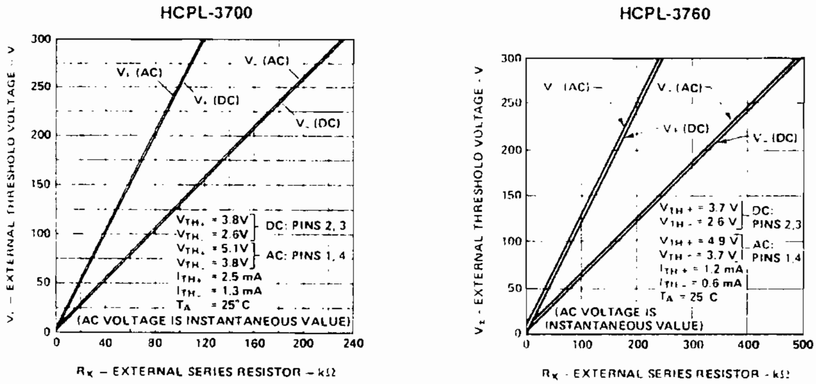

Figure 11. Typical External Threshold Characteristics, V± vs. R_x.

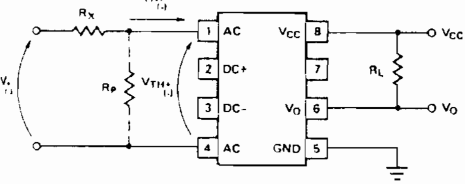

Figure 12. External Threshold Voltage Level Selection.

OPTOCOUPLERS

Electrical Considerations

The HCPL-3700/3760 optocouplers have internal temperature compensated, predictable voltage and current threshold points which allow selection of an external resistor, R_x, to determine larger external threshold voltage levels. For a desired external threshold voltage, $V_{\pm}$, a corresponding typical value of R_x can be obtained from Figure 11. Specific calculation of R_x can be obtained from Equation (1). Specification of both V_+ and V_- voltage threshold levels simultaneously can be obtained by the use of R_x and R_p as shown in Figure 12 and determined by Equations (2) and (3).

R_x can provide over-current transient protection by limiting input current during a transient condition. For monitoring contacts of a relay or switch, the HCPL-3700/3760 in combination with R_x and R_p can be used to allow a specific current to be conducted through the contacts for cleaning purposes (wetting current).

The choice of which input voltage clamp level to choose depends upon the application of this device (see Figure 1). It is recommended that the low clamp condition be used when possible. The low clamp condition in conjunction with the low input current feature will ensure extremely low input power dissipation.

In applications where $dV_{CM/dt}$ may be extremely large (such as static discharge), a series resistor, R_{CC}, should be connected in series with V_{CC} and Pin 8 to protect the detector IC from destructively high surge currents. See Note 13 for determination of R_{CC}. In addition, it is recommended that a ceramic disc bypass capacitor of 0.01 µf be placed between Pins 8 and 5 to reduce the effect of power supply noise.

For interfacing AC signals to TTL systems, output low pass filtering can be performed with a pullup resistor of 1.5 kΩ and 20 µf capacitor. This application requires a Schmitt trigger gate to avoid slow rise time chatter problems. For AC input applications, a filter capacitor can be placed across the DC input terminals for either signal or transient filtering.

Either AC (Pins 1, 4) or DC (Pins 2, 3) input can be used to determine external threshold levels.

For one specifically selected external threshold voltage level V_+ or V_-, R_x can be determined without use of R_p via

$$R_x = \frac{V_{+(-)} - V_{TH+(-)}}{I_{TH+(-)}} \quad (1)$$

For two specifically selected external threshold voltage levels, V_+ and V_-, the use of R_x and R_p will permit this selection via equations (2), (3) provided the following conditions are met. If the denominator of equation (2) is positive, then

$$\frac{V_+}{V_-} \geq \frac{V_{TH+}}{V_{TH-}} \text{ and } \frac{V_+ - V_{TH+}}{V_- - V_{TH-}} < \frac{I_{TH+}}{I_{TH-}}$$

Conversely, if the denominator of equation (2) is negative, then

$$\frac{V_+}{V_-} \leq \frac{V_{TH+}}{V_{TH-}} \text{ and } \frac{V_+ - V_{TH+}}{V_- - V_{TH-}} > \frac{I_{TH+}}{I_{TH-}}$$

$$R_x = \frac{V_{TH-}(V_+) - V_{TH+}(V_-)}{I_{TH+}(V_{TH-}) - I_{TH-}(V_{TH+})} \quad (2)$$

$$R_p = \frac{V_{TH-}(V_+) - V_{TH+}(V_-)}{I_{TH+}(V_- - V_{TH-}) + I_{TH-}(V_{TH+} - V_+)} \quad (3)$$